Counter track joint with optimised building space

Specification

The invention relates to a constant velocity joint in the form
of a counter track joint with the following characteristics:
an outer joint part having a first longitudinal axis and com-
prising first outer ball tracks and second outer ball tracks;
an inner joint part having a second longitudinal axis and com-
prising first inner ball tracks and second inner ball tracks;
the first outer ball tracks and the first inner ball tracks
form first pairs of tracks;
the second outer ball tracks and the second inner ball tacks
form second pairs of tracks;
the pairs of tracks each accommodate a torque transmitting
ball;
a ball cage is positioned between the outer joint part and the
inner joint part and comprises circumferentially distributed
cage windows which each receive at least one of the balls;
when the joint is in the aligned condition, the first pairs of
tracks open in the central joint plane in a first direction,
and when the joint is in the aligned condition, the second
pairs of tracks open in the central joint plane in a second
direction.

Counter track joints of the aforementioned type are basically
known from DE 102 20 711 A1, wherein joints with 6 balls and
with 8 balls are shown. The type of ball tracks here corre-
sponds to the type known from Rzeppa joints (RF joints) and
undercut free-joints (UF joints). This means that the center

lines of the ball tracks consist of uniform radii (RF joint) or consist of radii and adjacent axially parallel lines (UF joint). In the described counter track joints, the axial opening direction of the pairs of tracks alternates circumferentially, resulting in the type of counter track joint.

Known from DE 103 37 612 A1 are counter track joints in which the track center lines of the first pairs of tracks having an opening angle with an opening direction with aligned joint pointing toward the joint bottom designed in such a way that the opening angle experiences a reversal in its opening direction starting at a specific articulation angle when the joint is articulated. In particular, this is realized by virtue of the fact that the center lines of the ball tracks of the first pairs of tracks are S-shaped, and thereby each exhibit a turning point.

Known inter alia from DE 100 60 220 A1 are counter track joints in which the center lines of the first ball tracks have a turning point near the joint opening, so that the center lines of the first outer ball tracks are S-shaped. Due to the symmetry condition, the same holds true for the center lines of the first inner ball tracks of the joint inner part. The articulation angle of these counter track joints can be increased in this way.

Joints of the kind mentioned at the outset have been manufactured in various sizes, wherein the geometric conditions were derived from the available ball sizes taking into account the required torque capacity, using standard balls from ball bearing manufacture as the joint balls. In addition, the configuration of known joints has also been determined or influenced by the fitting dimensions of the available intermediate shafts, i.e., in particular the pitch circle diameter of the shaft splines of such intermediate shafts, and must correspond to the pitch circle diameter of the shaft splines in the joint inner part.

The object of this invention is to create a counter track joint of the kind mentioned at the outset optimized to the building space, which occupies the least possible radial building space at a given torque capacity.

A first solution for this object is for the ratio V1 between the pitch circle diameter PCDS of the shaft splines in the joint inner part to the third power and the product of ball diameter DK squared and pitch circle diameter of the balls with aligned joint PCDB assumes a value of between 0.9 and 1.3, i.e.,

$$0.9 < V1 < 1.3 \text{ with } V1 = PCDS^3 / (DK^2 \cdot PCDB).$$

In a second solution, the ratio V3 between the pitch circle diameter of the shaft splines in the joint inner part PCDS and the OR factor lies between 0.34 and 0.37, wherein the OR factor is defined as the sum of the pitch circle diameter of the balls PCDB with aligned joint and the ball diameter DK, so that

$$0.34 < V3 < 0.37 \text{ with } V3 = PCDS / (PCDB + DK).$$

The above approaches are based on postulations that the optimized configuration must have the necessary section modulus of the shaft splines in the joint inner part, and at the same time that the permissible load on the balls may not be exceeded taking into account the Hertz pressure, and finally that the outer diameter of the joint is to be kept low. To this end, the above approaches are used to indicate suitable configuration conditions with which these requirements are satisfied by selecting a large enough pitch circle diameter of the shaft splines and ball diameter, wherein the pitch circle diameter of the balls, being of importance besides the ball diameter for the outer diameter of the joint is designed as low as possible.

Each of the two approaches mentioned leads to the objective on its own. However, the result can be optimized by also using all two approaches in combination to further pinpoint the results according to the invention.

A preferred embodiment provides that the ratio V2 between the IR factor and the OR factor measures between 0.525 and 0.585, wherein the IR factor is defined as the difference between the pitch circle diameter of the balls with aligned joint PCDB and the ball diameter DK, and the OR factor is defined as the sum of the pitch circle diameter of the balls with aligned joint PCDB and the ball diameter DK, so that

$$0.525 < V2 < 0.585 \text{ with } V2 = (PCDB - DK) / (PCDB + DK).$$

In combination with at least one of the two aforementioned approaches, this dimensioning yields a particularly favorable result.

Another preferred embodiment further provides that the ratio V4 between the pitch circle diameter of the shaft splines in the joint inner part PCDS and the IR factor measures between 0.58 and 0.65, wherein the IR factor is defined as the difference between the pitch circle diameter of the balls with aligned joint PCDB and the ball diameter DK, so that

$$0.58 < V4 < 0.65 \text{ with } V4 = PCDS / (PCDB - DK).$$

In combination with at least one of the two aforementioned approaches, this dimensioning yields a particularly favorable result.

With respect to the forces on the ball cage and other properties that determine joint function, it has proven favorable to alternate the first pairs of tracks and the second pairs of tracks over the circumference of the joint.

The joint can be designed as a six-ball joint, and in a particularly favorable design, is an eight-ball joint. The joint is configured in a particularly advantageous way, wherein the articulation angle ranges from 25° to 45°, in particular from 30° to 40°. This stipulation means that the balls are still reliably slung in the inner and outer ball tracks within these articulation angle ranges, and that the first balls only start exiting the ball tracks at articulation angles exceeding these ranges.

The joint according to the invention can be designed as a disc joint with unilateral flanging on the joint outer part, or as a monoblock joint, wherein a joint bottom and shaft journal are integrally molded on the joint outer part.

Joints according to the invention can be used for the side shafts of motor vehicles that establish the connection between the differential output and wheel hub. In this case, there is a particularly favorable application as a differential-side fixed joint in such side shafts, which have two fixed joints and a plunging unit in the intermediate shaft.

Joints according to the invention can also be used in longitudinal drive shafts of motor vehicles that comprise at least one fixed joint and a plunging joint or at least two fixed hinges and a plunging unit.

Another preferred application involves multi-part longitudinal drive shafts in motor vehicles, which in addition to a fixed joint have at least one intermediate joint and a plunging joint and/or at least one intermediate joint and a longitudinal plunging unit.

Preferred exemplary embodiments of the invention are shown in the drawings, and will be described below.

Fig. 1 shows a counter track joint according to the invention with six balls, designed as a disc joint,
a) in an axial view
b) in a longitudinal section along the A-A line;

Fig. 2 shows a counter track joint according to the invention with eight balls, designed as a disc joint,
a) in an axial view
b) in a longitudinal section along the A-A line;

Fig. 3 shows a counter track joint according to the invention with six balls, designed as a monoblock joint,
a) in an axial view
b) in a longitudinal section along the A-A line
c) in a longitudinal section along the B-B line;

Fig. 4 shows a counter track joint according to the invention with eight balls, designed as a monoblock joint,
a) in an axial view
b) in a longitudinal section along the A-A line
c) in a longitudinal section along the B-B line;

Fig. 5 shows a drive shaft according to the invention with at least one joint according to the invention and a plunging unit in partial longitudinal section;

Fig. 6 shows an installation scenario according to the invention for a drive shaft according to Fig. 5 in a motor vehicle in partial longitudinal section;

Fig. 7 shows a longitudinal drive shaft according to the invention with a fixed joint according to the invention and a plunging joint in longitudinal half section;

Fig. 8 shows a longitudinal drive shaft according to the invention with a fixed joint according to the inven-

tion as an intermediate joint, another universal joint as an intermediate joint, and a plunging joint in longitudinal half section.

The two depictions on Fig. 1 will be described together below. The universal joint 11 according to the invention is designed as a so-called disc joint. It encompasses a joint outer part 12 with a first opening 13 and a second opening 14. The joint further encompasses a joint inner part 15, a ball cage 16 and torque-conveying balls 17. First outer ball tracks 18 in the joint outer part 12 and first inner ball tracks 19 in the joint inner part 15 accommodate balls 17_1 and form first pairs of tracks with each other. Second outer ball tracks 20 in the joint outer part 12 and second inner ball tracks 21 in the joint inner part 15 form second pairs of tracks with each other, which accommodate second balls 17_2. The two types of pairs of tracks (18, 19; 20, 21) are alternately arranged over the circumference. Six pairs of tracks are especially provided. The first pairs of tracks form an opening angle with each other that points in a first direction R_1 to the opening 13. The second pairs of tracks form an opening angle with each other that points in a second direction R_2 toward the opening 14. A center joint plane E that accommodates the centers P of the balls intersects the longitudinal axis of the joint defined by the longitudinal axes A_{12} of the joint outer part and A_{15} of the joint inner part in a joint center M. The ball cage 16 holds the first balls 17_1 and second balls 17_2 in alternating circumferentially distributed cage windows 24_1, 24_2. The pitch circle diameter on which the ball centers P lie with the aligned joint is denoted with PCDB. The pitch circle diameter of the insertion opening 27 of the joint inner part 15, which generally has shaft splines not shown here in detail, is denoted with PCDS. The ball diameter is marked DK.

The two depictions on Fig. 2 will be described together below.
The universal joint 11 according to the invention is designed
as a so-called disc joint. It encompasses a joint outer part
12 with a first opening 13 and a second opening 14. The joint
further encompasses a joint inner part 15, a ball cage 16 and
torque-conveying balls 17. First outer ball tracks 18 in the
joint outer part 12 and first inner ball tracks 19 in the
joint inner part 15 accommodate balls 17_1 and form first pairs
of tracks with each other. Second outer ball tracks 20 in the
joint outer part 12 and second inner ball tracks 21 in the
joint inner part 15 form second pairs of tracks with each
other, which accommodate second balls 17_2. The two types of
pairs of tracks (18, 19; 20, 21) are alternately arranged over
the circumference. Eight pairs of tracks are especially pro-
vided. The first pairs of tracks form an opening angle with
each other that points in a first direction R_1 to the opening
13. The second pairs of tracks form an opening angle with each
other that points in a second direction R_2 toward the opening
14. A center joint plane E that accommodates the centers P of
the balls intersects the longitudinal axis of the joint de-
fined by the longitudinal axes A_{12} of the joint outer part and
A_{15} of the joint inner part in a joint center M. The ball cage
16 holds the first balls 17_1 and second balls 17_2 in alternat-
ing circumferentially distributed cage windows 24_1, 24_2. The
pitch circle diameter on which the ball centers P lie with the
aligned joint is denoted with PCDB. The pitch circle diameter
of the insertion opening 27 of the joint inner part 15, which
generally has shaft splines not shown here in detail, is de-
noted with PCDS. The ball diameter is marked DK. Since two
first pairs of tracks (18, 19) are cut in plane A-A, the sec-
tionally depicted pairs of tracks both open in the first di-
rection R_1 toward the opening 13.

The individual depictions on Fig. 3 will be described together below. The same details as on Fig. 1 are labeled with the same reference numbers. Reference is made to the corresponding description. Instead of a second opening 14, the joint outer part 12 here has a formed-on bottom 25 followed by a shaft journal 26. The joint otherwise largely corresponds with the one shown on Fig. 1. A first (upper) and second (lower) pair of tracks is cut in a radially opposing manner in plane AA, while a second (upper) and a first (lower) pair of tracks is cut in a radially opposing manner in plane BB.

The individual depictions on Fig. 4 will be described together below. The same details as on Fig. 2 are labeled with the same reference numbers. Reference is made to the corresponding description. Instead of a second opening 14, the joint outer part 12 here has a formed-on bottom 25 followed by a shaft journal 26. The joint otherwise largely corresponds to the one shown on Fig. 2. Two second pairs of tracks (20, 21) are cut in the plane AA in a respectively radially opposing manner, while two first pairs of tracks (18, 19) are cut in a radially opposing manner in plane BB.

Fig. 5 shows a drive shaft that has a universal joint according to the invention as a monoblock joint based on one of Fig. 3 or 4, along with an intermediate shaft 35 and a second universal joint 31, which can also be a joint according to the invention, especially structurally identical with the joint 11. The intermediate shaft 35 encompasses an axial plunging unit 28, which consists of a sleeve 29, a journal 30 as well as torque-conveying balls active between the two and not denoted in specific detail as the essential components, and permits a longitudinal compensation of the drive shaft between the universal joints 11, 31.

Fig. 6 shows a drive shaft according to Fig. 5 installed as a side shaft in a motor vehicle. The shaft journal of the joint 11 according to the invention is inserted into a differential

gear 32 and secured therein, while the shaft journal of the second fixed joint 31 is inserted into a wheel hub arrangement 33 with a wheel mount 34. The same details are marked with the same reference numbers as on Fig. 5.

Fig. 7 shows a drive shaft according to the invention with a joint 11 according to the invention designed as a disc joint according to one of Fig. 1 or 2, which takes the form of a longitudinal drive shaft. An intermediate shaft 41 comprises a shaft tube 39 and two shaft journals 36, 37 welded thereto. The shaft journal 37 is connected with a plunging joint 38, in particular a so-called VL-joint. The shaft journal 36 is connected with the joint 11 according to the invention.

Fig. 8 shows a cardan shaft according to the invention with a joint 11 according to the invention designed as a disc joint according to one of Fig. 1 or 2, which takes the form of a longitudinal drive shaft, and has a disc joint 42, an intermediate shaft 43 with a flange 44 and a journal 45 from right to left, along with an elastic intermediate bearing 46, wherein the joint 11 is followed by another intermediate shaft 47 with a shaft journal 48, another intermediate bearing 49 and a universal joint 50; finally, there is another intermediate shaft 51 with shaft journals 52 connected with a universal plunging joint 53, in particular a VL-joint. Shafts of this kind are incorporated in the longitudinal drive train of motor vehicles between a gearbox output and a differential input.

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Reference list

11	Universal joint
12	Joint outer part
13	First opening
14	Second opening
15	Joint inner part
16	Ball cage
17	Ball
18	First outer ball track
19	First inner ball track
20	Second outer ball track
21	Second inner ball track
24	Cage window
25	Joint bottom
26	Shaft journal
27	Insertion opening
28	Plunging unit
29	Sleeve
30	Journal
31	Universal joint
32	Differential drive
33	Wheel hub
34	Wheel mount
35	Intermediate shaft
36	Journal
42	Rubber disc joint
43	Intermediate shaft
44	Flange

45	Shaft journal
46	Shaft bearing
47	Intermediate shaft
48	Shaft journal
49	Shaft bearing
50	Universal joint
51	Intermediate shaft
52	Shaft journal
53	Plunging joint